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Reducing VOCs From Wood Drying By Wet Line Extension

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Introduction

Volatile organics released from oriented strand board (OSB) and other furnishes during drying require expensive controls. The problem is especially acute for softwood, whose emissions, principally terpenes (1,2), exceed those from hardwood by an order of magnitude. Since the ratio of water:VOC released can depend upon several parameters, such as the presence of fines, options exist for lowering emissions without requiring major additional capital. A consortium comprising several forest products companies, electric utilities, and the Department of Energy are sponsoring work at the Institute on understanding the mechanism of VOC release from wood, and applying the results to optimize drying strategies and to select dryers. The specific objectives of this study were to (a) understand the factors that promote or retard VOC emissions as the furnish dries, (b) use this knowledge to reduce VOCs during drying, and (c) to develop methods for low VOC-drying. In this paper, we will interpret some of our findings in terms of a strategy for drying pine.

Experimental

OSB flakes were obtained from Georgia-Pacific facilities at Grenada, MS. and Dudley, NC. Sawdust was obtained from the Weyerhaeuser Adel, GA. plant. The principal component of these furnishes was loblolly pine. Two furnaces were used in this study. A tube furnace was utilized to dry small (< 8 g.) samples. Air was metered to the furnace at 2 lpm, and the entire furnace emissions were fed to a flame ionization analyzer (FIA). This unit is used in EPA Method 25A for monitoring total gaseous non-methane emissions. A 2,750 cu in. furnace was used to dry up to 5 lbs. of furnish. Air was injected through a manifold at the base of the furnace, and a sidestream from the emissions was analyzed by the FIA. The two furnaces are referred to in this study as the small and large furnaces, respectively.

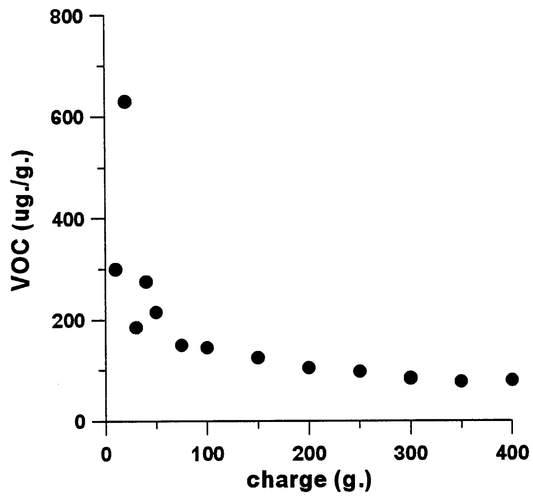

Figure 1: Dependence of VOC release on charge (wet basis)

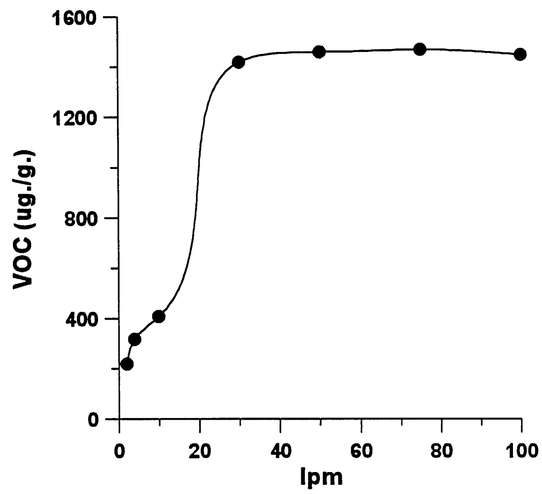

Figure 2: Dependence of emissions on flow rate (wet basis)

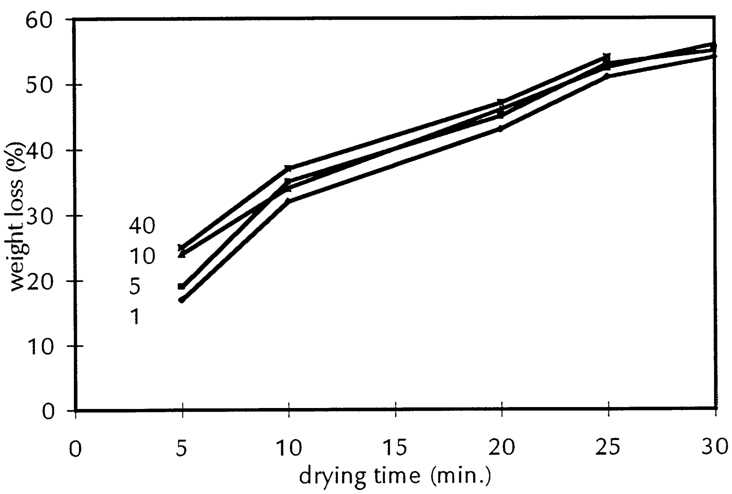

Figure 3: Effect of flow rate (lpm) on drying rate (wet basis)

Effect of flow rate on VOC emissions

Air was introduced at 4 lpm into our large furnace at 130°C, and VOCs were integrated over 1 hour. The results illustrated in Figure 1 show that smaller charges are associated with higher VOC. Except for the two highest weights in Figure 1, the furnish dried completely over the 1-hour period. Since the air flow in Figure 1 was constant, the smaller charge was associated with a higher air flow per gram of furnish. In order to isolate the effect of flow alone, the size of the charge was held constant and the air flow varied. VOCs from drying 10 g. of OSB at 130°C in our large oven for 1 hour are plotted against flow rate in Figure 2. Clearly, VOCs increase air flow, plateauing at about 30 lpm, which corresponds to 3 lpm/g. Flow rate affects the drying rate to a lesser degree as shown in Figure 3, where 50 g. of OSB were dried at flow rates of 1-50 lpm. Hence, we have the curious situation where increasing flow rate dramatically increases VOC loss, but affects the drying rate to a significant, but much smaller extent. While we are exploring the mechanism further, our working hypothesis is that the surface partially dries out at the higher flow rates. The local temperature in these micro-regions rise, and increased VOC loss occurs.

Effect of temperature on VOC emissions

OSB flakes were homogenized by coarse-grinding in a Wiley Mill to about 1″x3″. They were dried in the small furnace to various moisture end points and under various conditions of temperatures and drying periods, and the VOC /water loss determined for each charge. The results illustrated in Figure 4 show considerable scatter, but this is not unexpected given the variability in the furnish. However, it is clear that the amount of VOC released per unit of water lost is much higher at the higher temperatures, particularly after about 30% weight loss, which corresponds to the onset of the falling rate period, where transport of water to the surface becomes rate limiting (3,4). The results combined in the 3-D plot in Figure 5 more clearly illustrate that VOC release is roughly independent of temperature up to about 30% weight loss, beyond which VOC emissions increase with temperature.

In order to further develop the temperature-VOC relationship with a more uniform furnish, we dried sawdust in our small oven at 130-180°C for 1 hour. As with OSB, two signals were observed. The first emerged rapidly and corresponds to the period during which the flake temperature was below 100°C, i.e., the furnish was evaporatively cooled. The second appeared after the furnish was substantially dry and began to reach oven temperature (5). Consider the profiles in Figures 6-8, which represent VOC signals for sawdust between 130-160°C. Note that the maximum of the first signal remains at the same level of 1-1.4 μg/g. sec., but that the intensity of the second peak increases with temperature. The first signal represents VOCs released while water is still being lost; i.e. the material is evaporatively cooled to below 100°C regardless of the oven temperature. The second reflects VOCs given off after the furnish is much drier. The total VOC released over 1 hour correlates with temperature as illustrated in Figure 9. The intensity of the first peak is not temperature-dependent since the furnish temperature remains roughly constant regardless of the oven set temperature.

Figure 9 demonstrates that VOCs emerge through different mechanisms *from the same furnish*. One pathway is temperature dependent; the other is not. The initial signal reflects near-surface VOCs whose release is mediated by water, since the water and VOC profiles are very similar at temperatures exceeding 130°C (6). The second peak emerges when the water is mostly gone, and its temperature dependence implicates a vapor pressure driven mechanism. As noted previously (5), VOC emissions should be reduced if the furnish is dried just to the point of emergence of the second VOC signal.

Discussion

Although the mechanism through which flow rate influences VOC release is unknown, we hypothesize that dry regions develop on the surface at high flow rates. If so, then the temperature at these dry micro-regions will rise owing to the loss of evaporative cooling (5) and will promote VOC release. Support for this position comes from the temperature dependence data. The VOC rise in Figure 4 corresponds to the beginning of the falling rate regime when the surface becomes progressively less saturated, i.e., dry regions develop. The contrast in the behavior of the two signals in Figure 9 is also quite compelling. The initial signal is independent of the oven set temperature because of evaporative cooling during constant rate drying. The intensity of the second signal which is associated with late drying, increases with temperature, and is responsible for the increase in overall VOCs. Again, VOCs increase when the furnish (or portions therein) dry out.

From a practical point of view, it seems that a <u>uniform</u> reduction of moisture in the furnish during drying will reduce VOCs. Again, while the mechanism underlying these relationships is unknown, surface drying will impede the transport of interior moisture to the surface. Hence, evaporative cooling of the surface will be diminished, and the surface temperature will rise, at least in certain regions. While the conditions that govern VOC loss are complex, we know that a VOC surge occurs when the flake is largely dry and the flake temperature rises (5). Thus, prolonging the onset of the temperature rise will retain the VOC in the flake and decrease the VOC:water loss ratio. We note that this is not necessarily a panacea, since the retained VOCs may well increase press vent emissions, a possibility that we plan to explore.

The optimum drying strategy should minimize temperature imbalances and moisture gradients within the flake in order to reduce "dry spots", since these regions will release a higher proportion of VOCs. Since surface dry-out will impede the movement of water to the surface, it should be avoided, or its onset delayed.

Conclusions

The principal theme that emerges from this work is that the wet line should be maintained at the surface for as long as possible to keep the furnish evenly wet during drying. Practical observations support this position. It appears that lower VOCs are associated with drying with a lower temperature conveyor system or with superheated steam, both of which tend to keep the wet line at the flake surface.

Acknowledgments

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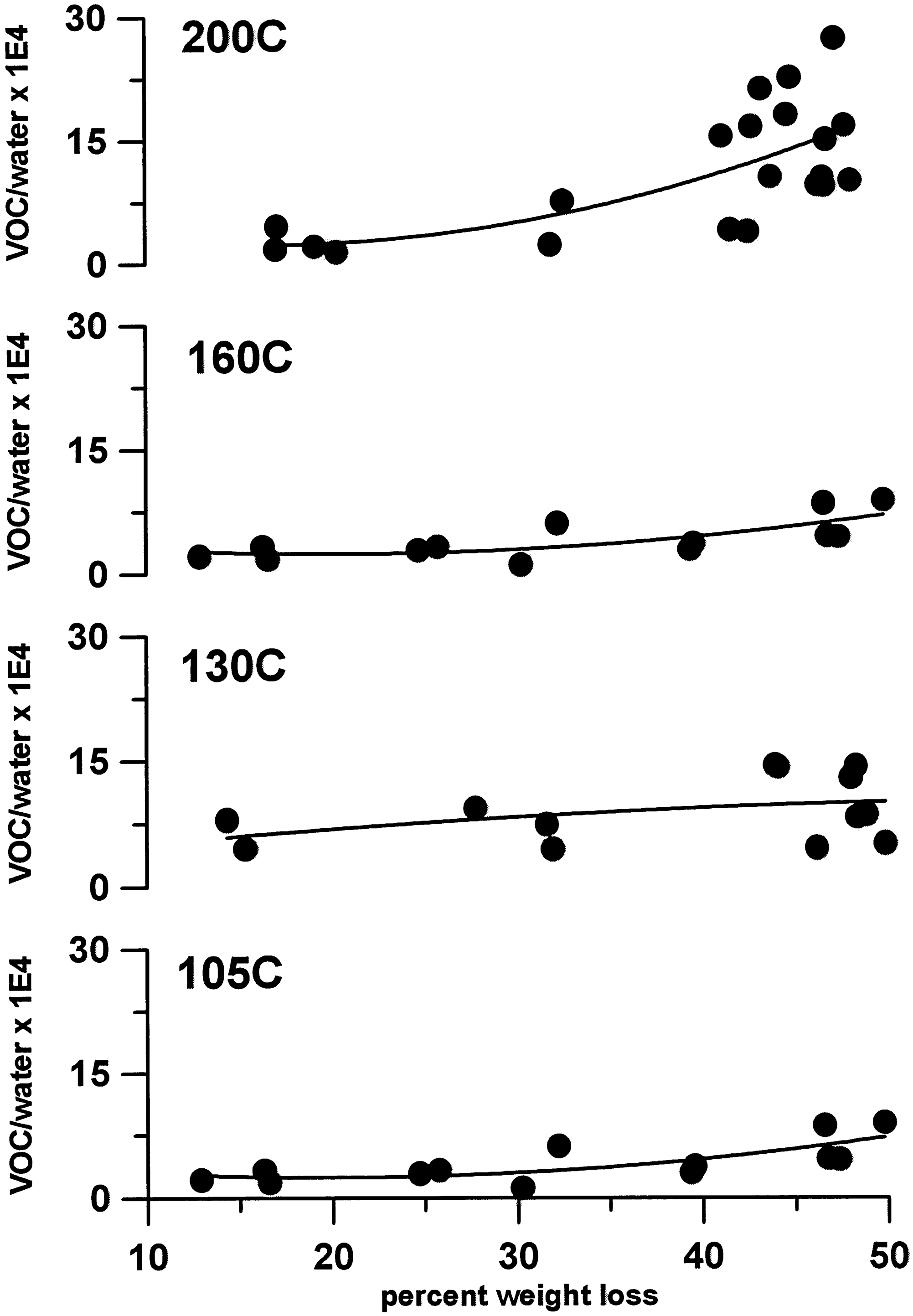

Figure 4: VOC/water ratios for OSB as a function of temperature and moisture content (initial wet basis moisture ≈ 50%)

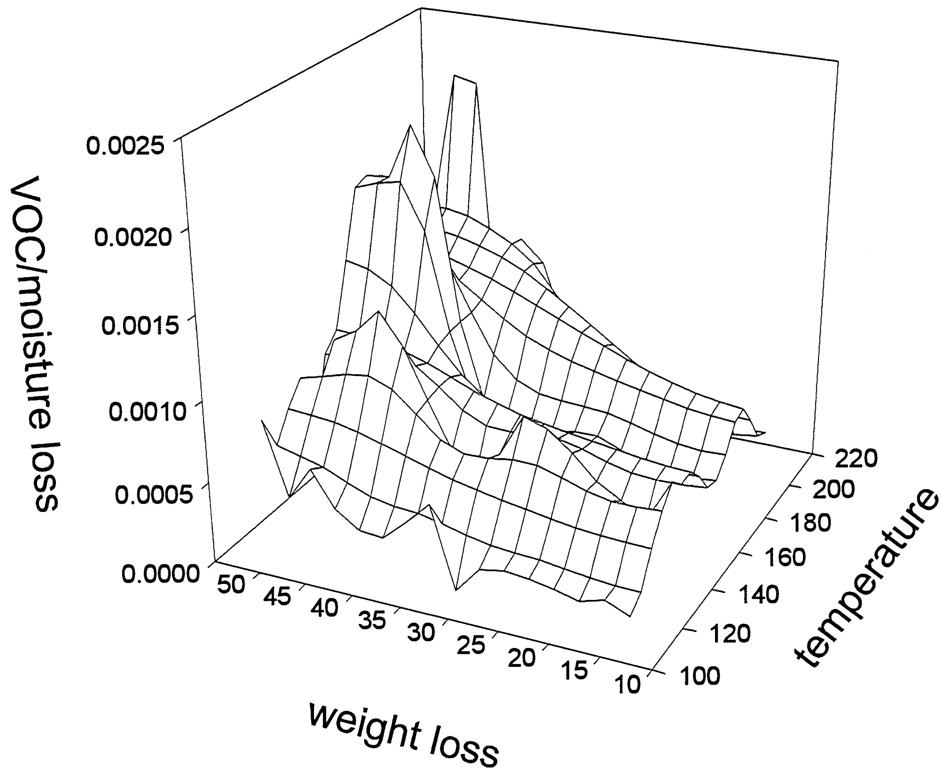

Figure 5: Relationships among VOC:water ratio, temperature and wet basis moisture content (constructed from the Figure 4 data)

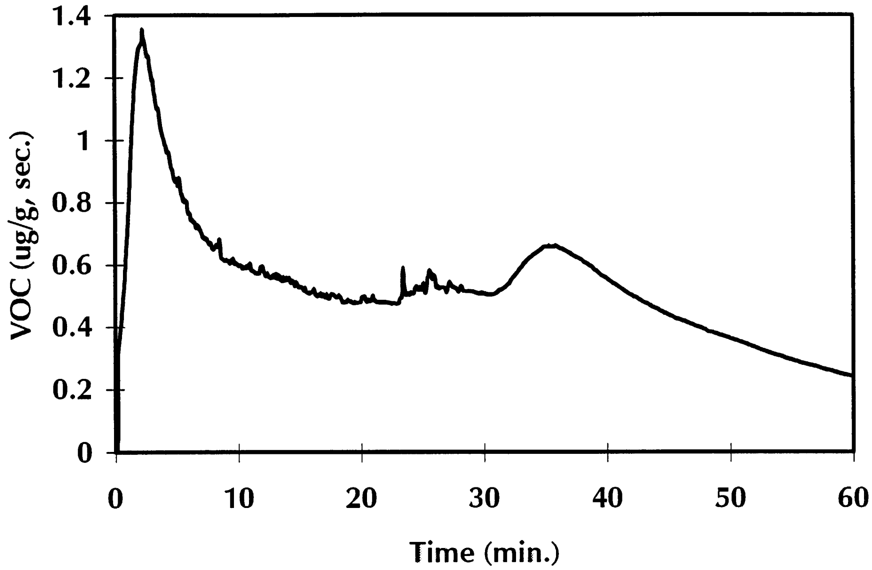

Figure 6: VOCs from sawdust at 130°C

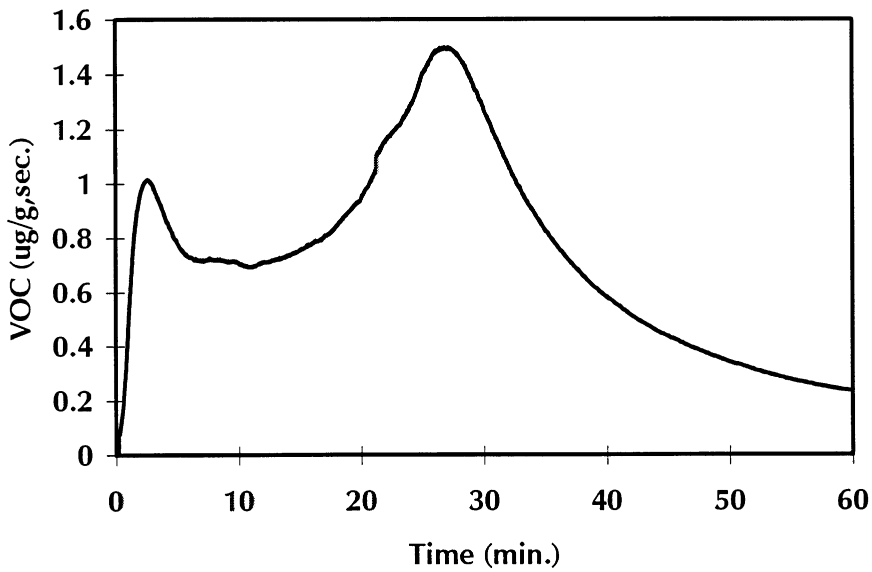

Figure 7: VOCs from sawdust at 160°C

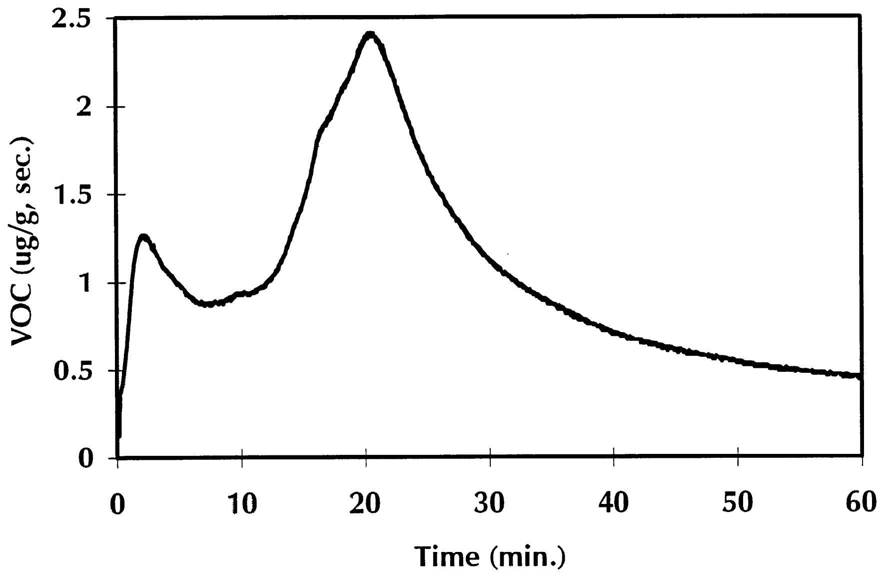

Figure 8: VOCs from sawdust at 180°C

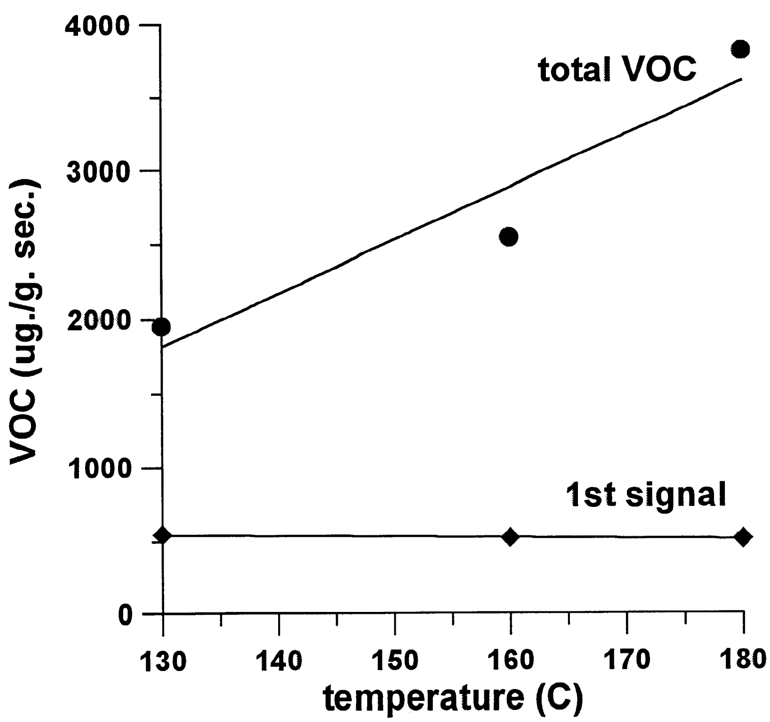

Figure 9: Dependence of VOC release on temperature for sawdust